Synthesis of Intervention Research to Modify Physical Activity and Dietary Behaviors

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Abstract:

A descriptive literature review was conducted to examine conceptual and methodological issues of interventions aimed at improving both physical activity and diet behaviors according to critical elements established by Sidani and Braden (1998). The method of the review of 30 articles describing 17 intervention studies focused on the following nine elements: (a) relevance of the intervention to the targeted outcome; (b) theoretical components of the intervention; (c) intervention components; (d) complexity, strength, and integrity of the intervention; (e) extraneous factors; (f) adherence to the intervention and retention; (g) reliability and validity of the outcome measures; (h) expected outcomes; and (i) effectiveness of the intervention. The results were that the interventions were relevant and included multiple components, but most interventions lacked an explicit theoretical framework. Adherence to the intervention and retention were problems. Overall, to varying degrees and for those completing the programs, the interventions were effective for increasing physical activity, lowering dietary fat, weight loss, and reducing risk for illness. Twelve "lessons learned" evolved that have practical and research implications. One salient lesson and future priority is to incorporate theory to reveal the intervention content and mechanisms to modify physical activity and dietary behaviors concurrently so that future interventions are more efficacious and efficient. Another lesson revealed the need for more sensitive measures, and examination of ways to improve intervention adherence and retention and prevent relapse.
Keywords: physical activity; dietary behavior; intervention research; health behavior research

Article:

Sedentary lifestyles and poor dietary habits are associated with overweight and obesity that are linked to a number of chronic illnesses, including diabetes, heart disease, hypertension, stroke, musculoskeletal disorders, and some types of cancer, as well as early mortality (Mokdad et al., 1999; Seidell, Kahn, Williamson, Lissner, & Valdez, 2001). National recommendations and clinical practice guidelines identify physical activity and healthy dietary habits as significant targets for controlling chronic diseases (American College of Sports Medicine, 2001; American Diabetes Association, 2004; U.S. Department of Health and Human Services RJSDHHS], 1998, 2001).

Although physical activity and diet are modifiable behaviors and improving them would reduce the risk of obesity and chronic disease, individual and programmatic efforts to increase physical activity or improve diet have met with limited success (National Center for Health Statistics, 2001). Interventions in naturalistic settings aimed at helping individuals to make changes in either of these two areas have been difficult to implement (Glanz, 1999; Pate, Heath, Dowda, & Trost, 1996; Redland & Stuifbergen, 1993). Historically, intervention research in physical activity and research in dietary behavior change have progressed independently (Wetter et al., 2001). However, the primary prevention of obesity requires individuals to consider making lifestyle changes in both physical activity and diet simultaneously. Recommendations to focus on two or more behaviors concurrently are congruent with recommendations of the Behavior Change Consortium (Ory, Jordan, & Bazzarre, 2002). No research synthesis of interventions that address both physical activity and diet has been published previously.

The purpose of this article is to report on a descriptive review. A descriptive review is warranted when a research area is new, when there are relatively few studies in the area, when the studies are diverse on multiple dimensions such as demographic variables and methods, and when the results are highly variable. This synthesis critically examines conceptual and methodological issues related to research on physical activity and dietary behaviors. The synthesis focuses on "process variables" in order to guide practice, future intervention development, and research. Focusing on process variables or internal validity is important according to Campbell and Stanley (1963) because "Internal validity is the basic minimum without which any experiment is uninterpretable" (p. 5). Internal validity, according to Vogt (1993), can be defined as "The extent to which the results of a study . . . can be attributed to the treatments rather than to flaws in the research design; in other words, the degree to which one can draw valid conclusions about the causal effects of one variable on another" (p. 114).

METHOD

REVIEW ORGANIZATION AND SYNTHESES

Cooper's (1998) method was used to conduct the integrated review of research. The five stages in his method include deciding on the subject of interest, searching the literature, assessing the quality of the studies, analyzing and interpreting the selected studies, and summarizing the findings. This descriptive review process was conducted according to Sidani and Braden (1998), who provided elements for reviewing studies. This "criterion referenced strategy" compared studies to these elements or standards. The studies were examined according to the following nine elements: (a) relevance of the intervention to a targeted outcome; (b) theoretical mechanisms underlying the intervention effects; (c) intervention components; (d) level of complexity, strength, and integrity; (e) extraneous factors; (f) implementation issues related to adherence to the intervention and retention in the study; (g) reliability and validity of the outcome measures; (h) expected outcomes; and (i) efficacy of the intervention.

INCLUSION CRITERIA

Inclusion criteria for studies in this review were as follows: (a) published research of an intervention that focused both on physical activity and dietary behaviors of adults in naturalistic settings; more specifically, activity-related interventions of supervised or unsupervised activities and both exercise and lifestyle physical activity; dietary behaviors generally assumed to be those including any diet either high in a variety of grains, fruit and vegetables, or low in sugar and fats (U.S. Department of Agriculture and USDHHS, 2000); (b) articles written in English and published between January 1993 and December 2003; (c) interventions restricted to healthy adults (18 years or older); (d) worksite studies that included additional behavior change interventions (e.g., smoking cessation) because it is typical for worksites to offer multiple interventions; and (e) diversity in setting, gender, socioeconomic status, or ethnic/cultural group.

SEARCH STRATEGY

The electronic databases searched to identify studies congruent with the inclusion criteria were Cumulative Index to Nursing and Allied Health Literature (1994-2004), Medline/PubMed (National Library of Medicine, 1997-2004), and PsychINFO (American Psychological Association, 1966-2004). The keywords used were physical activity and diet intervention, intervention studies, health promotion, obesity prevention, obesity control, lifestyle intervention, weight change, weight loss, and weight maintenance. Reference lists of retrieved articles were examined for additional intervention studies that fit the inclusion criteria and additional relevant articles were retrieved.

DATA EXTRACTION

The initial step in organizing information according to the elements of Sidani and Braden (1998) was to extract information from each published report onto a standardized data collection form. The information that was extracted included the following: (a) author's last name(s), journal, year published, and title of the intervention; (b) characteristics of the study setting including information about the location (e.g., urban or rural, worksite, clinic, community) and whether the study was multi- or single-site; (c) characteristics of the sample to include participants' mean age or age range, gender, racial or ethnic group, education, and socioeconomic status; (d) the

targeted behavioral outcome (i.e., physical activity and diet change) as well as additional indicators of behavior change (e.g., physiologic changes); (e) the reliability and validity of the outcome measures, recorded from the intervention report or from other references describing the psychometric properties of the measures; (0 information about the research design according to basic designs (Campbell & Stanley, 1963); (g) details about the treatment and control groups; and (h) statistical analyses and the direction of statistical outcomes for each of the two behaviors.

DATA SYNTHESES

A "vote-counting" procedure recommended by Cooper (1998) was used to synthesize characteristics of the interventions. Counts were quantified according to the total number of intervention studies and percentages reported. Direction of the intervention outcome also was reported for each of the two behaviors. Both of the two behaviors of interest were categorized as either significant in the hypothesized direction (= positive), statistically significantly in the direction opposite the hypothesis (= negative), or not significant (= *ns).*

RESULTS

INTERVENTION DESCRIPTION

Table 1 (page 30) presents 30 articles describing 17 interventions. Different aspects such as methods/procedures of an intervention were reported in more than one article. Of the 17 that reported results of the interventions, seven (41.2%) were conducted in communities (Jeffery & French, 1997; Mau et al., 2001; Narayan et al., 1998; Simkin-Silverman, Wing, Boraz, Meilahn, & Kuller, 1998; Jakicic, Winters, Lang, & Wing, 1999; Skender et al., 1996; Wing, Venditti, Jakicic, Polley, & Lang, 1998), four (23.5%) in worksites (Campbell et al., 2000; Emmons, Marcus, Linnan, Rossi, & Abrams, 1994; French et al., 1994; Haus, Hoerr, Mavis, & Robison, 1994), two (11.8%) in weight loss or medical clinics (Garaulet, Perez-Llamas, Zamora, & Tebar, 1999; Oldroyd et al., 2001), two (11.8%) were a combination of community and clinical recruitment (no setting specified) (Racette, Weiss, Obert, Kohrt, & Holloszy, 2001; Wylie-Rosett et al., 2001), and two (11.8%) were national clinical trials (Diabetes Prevention Program Research Group (DPPRG), 1999; Stevens et al., 1993). Investigators in all of the studies assessed the effectiveness of the inter-vention to improve health outcomes (e.g., blood pressure, body mass index [BMII, glucose tolerance) and/or health behaviors (physical activity and diet). Primarily researchers used self-report such as questionnaires (Campbell et al., 2000; French et al.; Garaulet et al., 1999; Haus et al., 1994; Hebert et al.; Jakicic et al.; Simkin-Silverman et al., 1995; Stevens et al.; Wing et al., 1998; Wylie-Rosett et al.), or activity and diet diaries (Emmons, Marcus, Linnan, Rossi, & Abrams, 1994; Jeffery et al., 1993; Mau et al., 2001; Narayan et al., 1998) to assess physical activity and nutrition intake.

RESEARCH DESIGNS

The majority *(n* = 12, 75.0%) of studies used a randomized controlled trial design (Table 1) (Abrams et al., 1994; Campbell et al., 2002; DPPRG, 1997; Hebert et al., 1995; Jeffery and French, 1997; Narayan et al., 1998; Oldroyd et al., 2001; Simkin-Silverman et al., 1995; Skender et al., 1996; Stevens et al., 1993; Wing et al., 1998; Wylie-Rosett et al., 2001). In three (18.8%) of these 12 studies, randomization was done at the worksite, not the individual level (Abrams et al., 1994; Campbell et al., 2000; Jeffery et al., 1993;).

Seven (41.2%) of the 17 studies were quasi-experimental designs (Mau et al., 2001; French et al., 1994; Garaulet et al., 1999; Haus et al., 1994; Jakicic et al., 1999; Jeffery et al., 1993; Racette et al., 2001). One (20%) of these quasi-experimental studies, conducted by Racette and colleagues (2001), was a matched control worksite intervention design; one (20%) study randomized subjects into three exercise groups (Jakicic et al., 1999), one (20%) study by Mau and colleagues (2001) was a nonrandomized design to assign two communities to the study groups; and two (40%) of the studies used a one-group pre-posttest design (Garaulet et al., 1999; Haus et al., 1994).

Table 2 (page 36) displays characteristics of the intervention, control conditions, and intervention effects. In the experimental studies, control conditions varied and involved the following: (a) Usual care including a "minimal intervention" about physical activity and diet were used as a control condition in four (23.5%) studies (DPPRG, 2002; Emmons, Linnan, Shadel, Marcus, & Abrams, 1999; Lasser et al., 1995; Racette et al., 2001); (b) self-

help guides with information about diet, physical activity, and behavioral strategies in two (11.8%) studies (Wing et al., 1998; Wylie-Rosett et al., 2001); (c) a waiting-list control with the intervention given after the posttest in two (11.8%) studies (Campbell et al., 2000; Skender et al., 1996); and (d) a "no treatment" control condition, which was used in the remaining four (23.5%) studies (Jeffery & French, 1997; Kuller, Simkin-Silverman, Wing, Meilahn, & Ives, 2001; Narayan et al., 1998; Oldroyd et al., 2001).

SAMPLE SIZE AND DEMOGRAPHIC DATA

Sample sizes were from 29 (Haus et al., 1994) to 3,234 (DPPRG, 1999) participants. Fourteen (82.4%) studies provided gender data. More women *(M* % = ~67.1%) participated than men, and in three (17.6%) studies, the intervention was offered to women only (Campbell et al., 2000; Jakicic et al., 1999; Simkin-Silverman, 1995). There was a greater proportion of male than female volunteer participants in only three (17.6%) studies (Appel et al., 1995; Emmons et al., 1994; Oldroyd et al., 2001). Of the nine (52.9%) studies that reported race or ethnicity, three (33.3%) specified race or ethnic group (Mau et al., 2001; Narayan et al., 1998; Racette et al., 2001) and six (66.7%) focused mostly on Caucasians (Appel et al., 1995; DPPRG, 2002; Emmons et al., 1999; Haus et al., 1994; Simkin-Silverman et al., 1998; Wylie-Rosett et al., 2001).

Four (23.5%) studies reported education. In three (75.0%) of these four studies, participants were mostly college educated (Appel et al., 1995; Simkin-Silverman et al., 1998; Wylie-Rosett et al., 2001). More blue-collar workers (who are often not college educated) participated in two (66.7%) of the three worksite intervention studies (Campbell et al., 2002; Emmons et al., 1999). All three studies reported worker status, and one of the four studies focused on blue-collar women in a rural manufacturing worksite (Campbell et al., 2002).

TABLE 1. Summary of Intervention Studies That Included Both Physical Activity and Diet

Study	Setting & Sample	Study Purpose
Abrams et al. (1994); Emmons et al. (1994, 1999) Working Healthy Project	Matched-pair worksites *n* = 22 paired worksites *n* = 2291 workers 92.6% Caucasian Men T = 57.8%, C = 52.1% Blue-collar workers T = 51.9%, C = 54.4%	Promote multiple healthy behaviors
Appel et al. (1995); Hebert et al. (1995); Lasser et al. (1995); Stevens et al. (1993, 2001) Trials of Hypertension Prevention	Multi-center national study conducted at clinics *n* = 2382 overweight/obese adults *M* BMI 30.9 kg/m^2 *M* age 43.6 years 79.3% Caucasian 34.3% women 86% college educated	Prevent hypertension
Campbell et al. (2000, 2002) Health Works for Women Project	Rural manufacturing worksites Blue-collar women *n* = 859 *M* age 38 years 57% African American	Promote multiple healthy behaviors
Diabetes Prevention Program Research Group (1999, 2002) Diabetes Prevention Program	Multi-center national study Adults at risk for diabetes *n* = 3234 (27 centers) *M* age 50.6 years 54.7% Caucasian 19.9% African American 15.7% Hispanic 67.7% women	Prevent diabetes
French et al. (1994); Jeffery et al. (1993); Schmitz et al. (1997) Healthy Worker Project	*n* = 32 worksites *M* age 38 ~53% women < 20% blue-collar ~19% < high school	Promote multiple healthy behaviors
Garaulet et al. (1999)	Weight-loss clinic *M* BMI 28.8 kg/m^2 *n* = 90 *M* age 37 years 77.8% women	Weight loss

Variable Measures	Design	Adherence to the Intervention and Retention
Stage of readiness for behavior change PAQ BFFC	RCT, matched-pair (randomized worksites) Used cohort data T - multilevel intervention C - self-help	Adherence: 90% attendance during intensive beginning phase. Median number of sessions attended at 6 months = 12; 6–18 months = 11; 18–36 months = 7.5 Retention: 51% from baseline to interim 38% from baseline to final survey
BP Weight WHC-ratio Urinary na^+ excretion Diet 24-hour recall PA diary	RCT 4 groups: T_1 - weight loss T_2 - sodium reduction T_3 - weight loss/sodium reduction C - usual care Variables measured every 6 months over 3–4 years	Adherence: 64% attended ≥ 80% sessions Retention: 90% at 14 weeks 55.6% at 6 months 40% at 12 and 18 months > 90% makeup contacts at 6 and 18 months
BMI 10-item checklist (METs) BFFC Stages of change Behavior change choice	RCT T - tailored computer messages + peer helpers C - 6-mo. delayed intervention with tailored computer message only	Adherence: NR Retention: 62.6% at 18 mo. T = 76.8; C = 90.5%
BMI Glucose, HBA_{1c} MAQ (METs) BFFC	RCT 3 groups: T_1 - metformin T_2 - intensive lifestyle BM C	Adherence: 74% physical activity at 24 weeks; 58% at most recent visit; diet NR Retention: 92.5%
BMI EFR (METs) NHANES	Random assignment of worksites to T; data from randomly selected employees (n = 200) from each worksite	Adherence: NR Retention: 35.5% at 2 years
BMI Weight Reasons for drop-out	QE (pre-posttest)	Adherence: NR Retention: 43% at 5 months

(*continued*)

TABLE 1. Continued

Study	Setting & Sample	Study Purpose
Haus et al. (1994)	University employees *n* = 29 *M* age 49 years 93.1% Caucasian 51.7% women	Weight loss
Jakicic et al. (1999, 2002)	Community recruitment *n* = 148 100% women age range 25–45	Weight loss
Jeffery & French (1997) Pound of Prevention Study	Community recruitment *n* = 822 72.3% women (49.1% low-income)	Weight loss
Mau et al. (2001) Native Hawaiian Diabetes Intervention Program	2 communities Native Hawaiians at risk for diabetes *n* = 147 *M* age T = 47.9, C = 51.3 years 69% women	Prevent diabetes
Narayan et al. (1998) Pima Action and Pima Pride	Gila River Indian Community Obese Pima Indians *n* = 95 BMI T = 36.5, C = 33.2 *M* age T = 34, C = 33 years T = 72.9%, C = 78.7% women	Prevent diabetes
Oldroyd et al. (2001)	Hospital in the UK Adults with impaired glucose tolerance *n* = 67 *M* age 57.9 years 56.7% men	Prevent diabetes

Variable Measures	Design	Adherence to the Intervention and Retention
Weight loss/regain history % weight change WHC NHANES FFQ (METs) Social support	QE (pre-posttest)	Adherence: NR Retention: NR
PAQ Accelerometer Exercise log Body composition (body scan) Girth BFFC Cardiovascular fitness	QE Randomized to 3 groups: Long-bout exercise Short-bout exercise Short-bout with home treadmill Prescribed diet for all 3 groups	Adherence: 67.1% to 71.7% attendance for the 3 groups Retention: 78% (no difference between groups)
Weight loss history Wt control practices BMI BP EFR (METs) BFFC Social support	RCT T_1 - Education only T_2 - Education + $100 lottery C	Adherence: class attendance 10% 72% at 1 year (assessed continued interest by postcard return) Retention: 86% at 1 year
MAQ (METs) FFQ adapted for Hawaiian population Stage of change	QE Nonrandomized with assignment of intervention to each of 2 communities	Adherence: NR Retention: NR
BP BMI WHC Glucose and insulin Pima-specific PA questionnaire (METs) Pima-specific diet recall	RCT T1 - PA and diet education C1 - Pima culture appreciation C2 - Observation only	Adherence: class attendance 25% at 6 months 17% at 12 months Retention: 95.8% T and 82.7% C at 12 months
4-day food diary PA (NR) Glucose tolerance Insulin sensitivity BMI WHC BP PA recovery pulse	RCT T - PA and diet counseling C - Usual lifestyle	Adherence: NR Retention: 95% T, 87% C at 6 months

(*continued*)

TABLE 1. Continued

Study	Setting & Sample	Study Purpose
Racette et al. (2001)	University medical center and community recruitment African-American adults at risk for diabetes *n* = 45 T *n* = 24 C Age 30 to 70 years BMI >27.0	Prevent diabetes
Kuller et al. (2001); Simkin-Silverman et al. (1995, 1998) Women's Healthy Lifestyle Project	Premenopausal women recruited from voter registration *n* = 520 *M* age 47 years 92% Caucasian 85% college education	Weight loss
Skender et al. (1996)	Community recruitment Overweight adults *n* = 127 Age 25 to 45 years	Weight loss
Wing et al. (1998)	Community recruitment Overweight adults (BMI ~36) *n* = 154 Age 40 to 55 years	Prevent diabetes
Wylie-Rosett et al. (2001)	Patients enrolled in an HMO and community recruitment BMI ≥ 25 + 1 CV risk factor *n* = 588 83% Caucasian 82% women 84% ≥ 1 yr. College	Weight loss

Note. BFFC = Block Food Frequency Checklist; BM = behavior modification; BMI = body mass index (kg/m^2); BP = blood pressure; C = comparison or control group; EFR = exercise frequency recall; FFQ = Food Frequency Questionnaire; HbA_{1c} = glycosylated hemoglobin; HDL = high-density lipoprotein; I = intervention group; LDL = low density lipoprotein; *M* = mean; MAQ = Modifiable Activity Questionnaire; METs = metabolic equivalents;

Variable Measures	Design	Adherence to the Intervention and Retention
MLTPAQ 7-day PA recall 7-day food diary BMI WHC % body fat Glucose tolerance	QE Intervention group (employees) with matched control (residents) Matched on obesity, glucose tolerance, educational level, and physical activity	Adherence: NR Retention: 82% T, 63% C at 4 months 60% T, 17% C at 8 months 42% T, 71% C at 1 year
7-day PA diary and Caltrac monitor Food diaries BMI Body fat WHC LDL-C Triglycerides Glucose BP	RCT T - lifestyle diet and PA BM C - usual lifestyle	Adherence: class attendance 76% at 5 months Retention: 91% at 18 months
Body weight change	RCT T_1 - diet alone T_2 - exercise alone T_3 - diet + exercise C - 3-month wait control	Adherence: 6.7% (diet only), 44% (exercise only), 14.3% (diet/exercise) reported adhering "often" to intervention condition Retention: 67.8% at 1 year, 48% at 2 years
PAQ (Mets) BFFC Fitness walk-test BMI WHC Glucose, HbA_1 Lipids BP	RCT T1 - diet alone T2 - physical activity alone T3 - diet + physical activity C - usual lifestyle	Adherence: class attendance 56% at 6 months, 27% after 6 months Retention: 85% at 6 months 78% at 1 year 84% at 2 years
PAQ (Mets) BFFC Dietary knowledge Barriers to change Self-efficacy BMI % body fat WHC Glucose Cholesterol/Triglycerides	RCT T_1 - workbook + computer T_2 - workbook + computer + staff consultation C - workbook only	Adherence: NR Retention: 81% at 12 months 84% workbook only 78% workbook + computer 93% workbook + computer + staff support

MLTPAQ = Minnesota Leisure Time Physical Activity Recall; NHANES = National Health and Nutrition Examination Survey; NR = not reported; PA = physical activity; PAQ = Paffenbarger Activity Questionnaire; QE = quasi-experimental; RCT = randomized clinical trial; T = treatment group; WHC = waist/hip circumference.

TABLE 2. Characteristics of the Intervention, Control Condition, and Intervention Effects

Study	Intervention Components	Theoretical Framework	Quantity of Activities
Abrams et al. (1994); Emmons et al. (1994, 1999) Working Healthy Project	Education Behavior change strategy Social strategy Organizational strategy	SCT, SS, TM Individual, organization, and community activation and diffusion theories. Intervention based on participatory strategies model	Kickoff event 2 brochures/posters per behavior 1 self-assessment with feedback Self-help materials Contests/incentives Group sessions Worksite campaigns Organizational support
Appel et al. (1995); Hebert et al. (1995); Lasser et al. (1995); Stevens et al. (1993, 2001) Trials of Hypertension Prevention, Phase II	Education Behavior change strategy Social strategy	SS	Intensive phase 1 individual session 14 group sessions 6 group sessions Extended phase 3–4 mini-modules
Campbell et al. (2000, 2002) Health Works for Women	Education Behavior change strategy Social strategy Organizational strategy	EM, SCT, SS, TM	2 individual computer programs with 13 "articles" Natural helper program
Diabetes Prevention Program Research Group (1999, 2002) Diabetes Prevention Program	Education Behavior change strategy Social strategy	NR	16 individual lessons Individual counseling
French et al. (1994); Jeffery et al. (1993); Schmitz et al. (1997) Healthy Worker Project	Education Behavior change strategy Social strategy Organizational strategy	NR	4 rounds of 11 sessions
Garaulet et al. (1999)	Education Behavior change strategy	NR	6 60-minute group sessions 5 20-minute group sessions
Haus et al. (1994)	Education Behavior change strategy	NR	60-minute group sessions

Frequency	Duration	Control Condition	Intervention Effects
NR NR Multi-sessions Ongoing Ongoing Ongoing Ongoing Ongoing	2.5 years	Standard care with self-help program on nutrition and physical activity	PA: + S Stage progression: +S Diet: fruits/vegetables, fiber + S; fats NS Stage progression: + S T/C differences: S T group regained weight between 6 and 18 months
Initial Weekly Biweekly 6/year	 2½–3 months 3–4 months 1 year	Usual clinic care	 Weight loss: + S BP: + S T/C differences: S
Baseline and 6 months Ongoing	6 months 18 months	6-month delayed with computerized program only	PA (aerobic): + NS at 6 and 18 months Diet: fruits/vegetables + NS at 6 months, + S at 18 months fat + S at 6 months, + NS at 18 months T/C differences: NS T group showed improvement throughout the 18 months
~Weekly Monthly	24 weeks ~3 years	Standard lifestyle with 20–30 minute annual individual session emphasizing physical activity and healthy diet.	PA: + S Weight loss: + S Lower incidence of diabetes: + S
Biweekly	2 years	No treatment	BMI: + NS Weight loss: + NS T/C differences: NS
Weekly for 6 weeks Monthly	6 weeks 5 months		Weight loss: + S Pre-post differences: + S
Weekly Bimonthly	6–8 weeks ~4 months		Weight loss: + S at post Tx Weight loss maintenance: - S at 6 to 42 months PA related to weight loss maintenance: + S 69% T regained weight after 6 months

(*continued*)

TABLE 2. Continued

Study	Intervention Components	Theoretical Framework	Quantity of Activities
Jakicic et al. (1999, 2002)	Education Behavior change strategy	NR	Home exercise Group meetings
Jeffery & French (1997) Pound of Prevention	Education Behavior change strategy	NR	2–4 page messages in newsletter 2 group sessions
Mau et al. (2001) Native Hawaiian Diabetes Intervention Program	Education Behavior change strategy Social strategy	SS	5 sessions 1 exercise class 'ohana support
Narayan et al. (1998) Pima Action and Pima Pride	Education Behavior change strategy	SS	Group sessions (# NR) Home visit
Oldroyd et al. (2001)	Education Behavior change strategy Organizational strategy	NR	1 session 3 15–20 minute review sessions 3 15–20 minute review sessions
Racette et al. (2001)	Education Behavior change strategy	NR	Phone contact Newsletters Group sessions (optional) Individual sessions
Kuller et al. (2001); Simkin-Silverman et al. (1995, 1998) Women's Healthy Lifestyle Project	Education Behavior change strategy	NR	15 individual sessions 10 individual sessions 6 group sessions Mail/phone contacts

Frequency	Duration	Control Condition	Intervention Effects
		No control	Weight loss: Short-bout + home exercise + S greater than Short- or Long-bout exercise at 13 and 18 months. + S correlation between higher levels of exercise (≥ 200 min./wk.) resulted in S greater weight loss. Modest, + S relationship between physical activity and healthy eating behaviors.
Weekly Biweekly Monthly	6 months 6 months 6 months		
Monthly NR	1 year	No treatment	Weight loss: + NS > weight gain in the low-income T than C < weight gain in men and high-income women T than C
Monthly Weekly Ongoing	6 months 6 months 6 months		Weight loss: + S at 18 and 36 months T/C differences: + S
Weekly Varied by need	12 months	Observation group	PA: + NS Diet: + NS T/C differences: NS T group maintained diet and physical activity to 12 months
Baseline Weekly Monthly	 4 weeks 5 months	No treatment	PA: + S Diet: + S BMI: + S BP: + S Insulin sensitivity: + S T/C differences: + S T group regained weight between 8 months and 1 year but weight still lower than baseline
Monthly Bimonthly Bimonthly As needed	1 year	1 instructional session	PA: NS BMI: NS Weight loss: + NS Glucose tolerance: + S
~Weekly ~Biweekly Monthly Every 2–3 months	20 weeks 6 months 14 months Over 5-year study period	No treatment	PA: + S at 6 and 18 months Diet: + S at 6 months and 18 months T/C differences: + S T group regained weight from 6 to 18 months

(*continued*)

TABLE 2. Continued

Study	Intervention Components	Theoretical Framework	Quantity of Activities
Skender et al. (1996)	Education Behavior change strategy	NR	12 60-minute group sessions 3 60-minute group sessions 3 60-minute group sessions
Wing et al. (1998)	Education Behavior change strategy Social strategy	NR	24 group sessions 24 group sessions 4 group sessions
Wylie-Rosett et al. (2001)	Education Behavior change strategy	TM	T_1: 20-minute computer sessions Workbook T_2: 20-minute computer sessions Workbook 6 group sessions < 18 phone/personal contacts

Note. BP = blood pressure; C = control group; EM = Ecological Model; NS = statistically not significant; NR = not reported; PA = physical activity; S = statistically significant;

RELEVANCE OF THE INTERVENTION TO THE TARGETED OUTCOME

Definition of the clinical problem, probable causative factors, and physiological rationale for diminishing the clinical problem with a physical activity and diet intervention were addressed in all studies. The prevention of diabetes was the purpose of six (35.3%) studies (DPPRG, 1999; Mau et al., 2001; Narayan et al., 1998; Oldroyd et al., 2001; Racette et al., 2001; Wing et al., 1998), weight loss the purpose of seven (41.2%) studies (Garaulet et al., 1999; Haus et al., 1994; Jakicic et al., 1999; Jeffery & French, 1997; Kuller et al., 2001; Skender et al., 1996; Wylie-Rosett et al., 2001), hypertension prevention the purpose one (5.9%) study (Appel et al., 1995), and the remaining three (17.6%) studies focused on general healthy behaviors to prevent multiple chronic illnesses (Campbell et al., 2002; Emmons et al., 1999; French et al., 1994).

INTERVENTION COMPONENTS

Table 2 summarizes the characteristics of the interventions. The intervention components were categorized into: (a) education to change knowledge or attitudes, (b) behavior change strategies to overcome barriers or otherwise facilitate behavior change, (c) social strategies including social support and socially supporting environments, and (d) organizational strategies including policy and environment. All interventions involved an education and behavior change component. The educational component focused on risk awareness in all studies, and on physical activity and healthy diet in six (35.3%) studies (Campbell et al., 2002; Garaulet et al., 1999; Jeffery & French, 1997; Oldroyd et al., 2001; Racette et al., 2001; Simkin-Silverman et al., 1995).

Self-control behavior change strategies included goal-setting and self-monitoring (Emmons et al., 1999; Garaulet et al., 1999; Jeffery et al., 1993; Simkin-Silverman et al., 1998; Skender et al., 1996; Stevens et al., 1993; Wing et al., 1998), problem-solving to overcome barriers (Simkin-Silverman et al., 1998; Wing et al., 1998), assertiveness training (Simkin-Silverman et al., 1998; Wing et al., 1998), relapse prevention strategies (Narayan et al., 1998; Simkin-Silverman et al., 1998; Stevens et al., 1993; Wylie-Rosett et al., 2001), and positive reinforcement (Emmons et al., 1999; Garaulet et al., 1999; Haus et al., 1994).

Frequency	Duration	Control Condition	Intervention Effects
Weekly	12 weeks	3-month delayed	Weight loss + S
Biweekly	2 weeks		< weight loss in exercise-only than diet-only; > weight loss in exercise + diet at 1 year
Monthly	3 months		Exercise-only maintained the weight loss; diet only and diet + exercise gained weight back, but diet + exercise weight was still below baseline at 2 years
Weekly	~12 months	Self-help manual with information on healthy diet, physical activity, and behavioral strategies	> weight loss and changes in variables in diet and diet + exercise group at 6 months
Biweekly	~12 months		
NR	2nd year		T/C differences: NS at 2 years
Weekly	3 months	Self-help workbook with information on healthy diet, physical activity, and behavioral strategies	PA: NS
			Diet: + NS
Self-determined	1 year		T/C differences NS for PA & diet; T/C differences + S for BMI with T_2 the most weight loss
Weekly	3 months		
Self-determined	1 year		
NR			
NR	1 year		

SCT = Social Cognitive Theory; SS = social support; T = treatment group; TM = Trans-theoretical Model of Behavior Change; + = positive direction; – = negative direction.

Six (35.3%) of the interventions encompassed a social component. Social sup-port was emphasized in five (29.4%) (Campbell et al., 2002; Emmons et al., 1999; Mau et al., 2001; Narayan et al., 1998; Stevens et al., 1993); and supervised walking sessions in one (5.9%) intervention (Wing et al., 1998). Organizational strategies comprised an additional component in five (29.4%) of the interventions. They included policy and environmental changes in two (11.8%) worksite interventions (Emmons et al., 1999; Jeffery et al., 1993), use of a home treadmill for exercise in one (5.9%) intervention (Jakicic et al., 1999), paycheck deductions and program refund for progress in outcome behaviors at another worksite intervention (Jeffery et al., 1993), and one (5.9%) community intervention offered discounts on fees for engaging in leisure activities (Oldroyd et al., 2001).

Reports of six (35.3%) studies identified individualization of the intervention to the participants (Campbell et al., 2002; DPPRG, 1999; Lasser et al., 1995; Oldroyd et al., 2001; Wing et al., 1998; Wylie-Rosett et al., 2001). All six of them used counseling for tailoring lifestyle changes. In addition, two (11.8%) studies used "self-administered" interventions in the way of a computer (Campbell et al., 2002) or workbook (Wylie-Rosett et al., 2001) to tailor the intervention. In one (5.9%) study (Campbell et al., 2002), a computerized intervention was used that was designed like a typical women's magazine and tailored to the needs and wants of individual female blue-collar employees. The content for the computerized messages was generated from a pre-intervention assessment of each woman and incorporated demographic, psychosocial, behavioral, and community-specific variables previously found to predict change in the outcome variables. In the other study (Wylie-Rosett et al.), a workbook was used as a tailored self-help guide as well as a tailored computer program. In only one (5.9%) study did the researchers include the participants in the design of the intervention to assure tailoring (Emmons et al., 1999). This study included diverse types of workers from 26 worksites in planning and implementing the intervention. In addition, employees were designated as advisory board and intervention coordinators at each of the worksites to oversee quality control by informally assessing the continued acceptability of the intervention to the workers.

Cultural tailoring of interventions is important because culture influences how people define or experience health, as well as their choice of health behaviors (USDHHS, 2000). Three (17.6%) studies used interventions targeted to racial/ethnic minority groups (Mau et al., 2001; Narayan et al., 1998; Racette et al., 2001). However, only one (5.9%) intervention, aimed at native Hawaiians, revealed cultural tailoring (Mau et al., 2001). This

intervention used a family support person *Cohana),* plus a culturally-tailored physical activity and diet intervention. In an intervention targeting Pima Indians, there was no indication of a culturally-tailored intervention, but an attention-control group was provided an education on Pima culture (Narayan et al., 1998).

COMPLEXITY, STRENGTH, AND INTEGRITY OF THE INTERVENTION

According to Sidani and Braden (1998), interventions with two or more components and those requiring advanced skills for delivery are considered complex. By this definition, all of the interventions were complex, having at least two components, education and behavior change strategies, and required interventionists to have counseling skills. Three (17.6%) had an additional social strategy component (DPPRG, 1999; Lasser et al., 1995; Mau et al., 2001), and one (5.9%) had an additional organizational component (Oldroyd et al., 2001). Three (17.6%) interventions had four components that included social and organizational strategies in addition to education and behavior change strategies (Abrams et al., 1994; Campbell et al., 1998, 2002; Jeffery et al., 1993).

Strength of the intervention refers to the intensity and duration (dose) needed to achieve the desired outcome(s) (Sidani & Braden, 1998). Intensity is the quantity of activities and the frequency with which these activities are carried out. Duration is the total length of time of the intervention. Intervention strength can be estimated from the Quantity of Activities, Frequency, and Duration shown in Table 2. Interventions were administered over periods from 5 months (Garaulet et al., 1999) to 5 years (Kuller et al., 2001). The level of intensity of the interventions varied between 42 (Narayan et al., 1998) and 52 (Wing et al., 1998) contacts with participants, and contacts were in the form of group or individual sessions. Interventions generally began with frequent contact followed by less frequent follow-up and reinforcement. In general, both intensive interventions and less intensive interventions resulted in positive outcomes, and interventions that had a more intensive maintenance phase were effective for a longer period of time than were shorter, less intensive interventions. As long as there was intervention, progress continued.

The integrity of an intervention refers to the extent to which it is fully delivered or implemented as planned (Yeaton & Sechrest, 1981). The more complex an intervention is and the more doses needed to achieve the effect, the greater the threat to the integrity of the intervention (Lipsey, 1990; Sidani & Braden, 1998). Some considerations were taken by the researchers to assure integrity of the intervention under evaluation. The use of protocol and uniform application of the intervention to the recipients were described in only five (29.4%) studies (Abrams et al., 1994; DPPRG, 2002; Garaulet et al., 1999; Jeffery et al., 1993; Lasser et al., 1995). Ten (52.9%) intervention reports either described using a standardized curriculum (DPPRG, 1999; Jeffery et al.; Skender et al., 1996), computer intervention (Campbell et al., 2002; Wylie-Rosett et al., 2001), or written materials (Garaulet et al.; Jeffery & French, 1997; Racette et al., 2001; Wing et al., 1998). The use of professionals to administer the intervention was identified in 13 (76.5%) studies (DPPRG, 2002; Garaulet et al., 1999; Jakicic et al., 1999; Jeffery et al., 1993; Jeffery & French, 1997; Lasser et al., 1995; Narayan et al., 1998; Oldroyd et al., 2001; Racette et al., 2001; Simkin-Silverman et al., 1995; Skender et al., 1996; Wing et al., 1998; Wylie-Rosett et al., 2001). When laypersons delivered the intervention, training and supervision were provided in only three of the 17 (17.6%) studies (Campbell et al., 2002; Emmons et al., 1999; Mau et al., 2001). Supervision of the interveners was reported in two (11.8%) studies (Campbell et al., 2002; Jeffery et al., 1993), and process evaluation relevant to integrity was described in three (17.6%) studies (Emmons et al., 1999; Lasser et al., 1995; Mau et al., 2001).

THEORETICAL COMPONENTS OF THE INTERVENTION

Sidani and Braden (1998) assert that theory should guide intervention planning, interpretation, and application of findings in clinical practice. Although factors known to influence behavior change were discussed in some of the reports, explicit theoretical models used to guide the intervention were identified in only six (35.3%) studies (Appel, 1995; Campbell et al., 2000; Emmons et al., 1999; Mau et al., 2001; Narayan et al., 1998; Wylie-Rosett et al., 2001). Campbell and colleagues (2000, 2002) based their intervention on an ecological model (McLeroy, Bibeau, Steckler, & Glanz, 1988) that identified individual characteristics and social/environmental support as influencing effects of the intervention on the desired out-comes. Within the broader framework of the ecological

model, the researchers used Social Cognitive Theory (Bandura, 1989) and the Transtheoretical Model of Behavior Change (Prochaska, DiClemente, & Norcross, 1992) to guide the design of the intervention component aimed at individual behaviors, as well as the Social Support Model (Israel, 1985) to guide the design of the social environmental component of the intervention. Campbell and colleagues (2000, 2002) used formative research to elicit tailoring variables, message content, and format for computerized and individualized interventions and to educe worksite peers to facilitate information dissemination and social support for the behavior change.

The Working Healthy Project (Emmons et al., 1999) was based on a community public health model that assumes people are more likely to participate when they have been involved in planning and implementing an activity. An ecological model was inferred because the intervention focused on individual, social, and environmental/policy influences such as skill-building, social support, and low-fat foods in vending machines, respectively.

Three interventions were based on the Transtheoretical Model of Behavior Change (Mau et al., 2001; Oldroyd et al., 2001; Wylie-Rosett et al., 2001). Interventions were individually tailored to the participant's stage of change/readiness in relation to each of the two behaviors (physical activity and dietary). Using the Transtheoretical Model of Behavior Change, Mau and colleagues (2001) found stage of change positively related to physical activity and dietary intake of fat and fiber. They also found that the social support intervention was effective in advancing people from the contemplation to the action stage of behavior change, but it was not effective in maintaining behavior in the first year post-intervention.

Other researchers did not identify an explicit theoretical model that guided the development of their intervention, but five (29.4%) studies did use approaches tacitly based on behavioral theories. Three (17.6%) of them based their interventions broadly on self-control principles such as self-monitoring and goal-setting, stimulus control, social support, problem-solving, and relapse prevention (Garaulet et al., 1999; Lasser et al., 1995; Simkin-Silverman et al., 1998). Another study (5.9%), the Diabetes Prevention Program (1999), was a lifestyle intervention that used behavior modification concepts tailored to individual needs and culture, and used additional sessions for behavior reinforcement. In the last study (5.9%) by Narayan and colleagues (1998), self-efficacy was not explicitly identified as a target, but the intervention designed to reduce the risk for diabetes in Pima Indians introduced and promoted activities congruent with Social Cognitive Theory (Bandura, 1989) of observational and active learning techniques such as modeling, role-play, and food preparation.

EXPECTED INTERVENTION OUTCOMES

All of the studies specified expected behavioral and/or physiological outcomes of the physical activity and dietary interventions. Outcome variables in six (35.3%) studies used both changes in physical activity and diet behaviors as well as physiologic assessments (DPPRG, 2002; Jakicic et al., 2002; KuIler et al., 2001; Oldroyd et al., 2001; Wing et al., 1998; Wylie-Rossett et al., 2001). Three (17.6%) studies only used physical activity and diet variables (Campbell et al., 2002; Emmons et al., 1999; Narayan et al., 1998). Physiologic assessments (e.g., weight change, BMI, body com-position with a body scan, blood pressure, and blood glucose) were the outcome variables in nine (52.9%) studies (Appel et al., 1995; French et al., 1994; Garaulet et al., 1999; Haus et al., 1994; Jakicic et al., 2002; Jeffery & French, 1997; Mau et al., 2001; Racette et al., 2001; Skender et al., 1996).

In the seven (41.2%) studies in which the purpose was to examine the effectiveness of physical activity and dietary modifications to prevent a specific disease, the outcome was based on a physiologic theory (physiologic evidence) related to that disease (DPPRG, 2002; Mau et al., 2001; Narayan et al., 1998; Oldroyd et al., 2001; Racette et al., 2001; Stevens et al., 2001; Wing et al., 1998). In four (23.5%) studies, the purpose was to promote multiple healthy behaviors to influence physical activity, diet, and/or weight (Campbell et al., 2002; Emmons et al., 1999; Jakicic et al., 1999; Schmitz et al., 1997). The remaining six (35.3%) studies focused on weight loss (Garaulet et al., 1999; Haus et al., 1994; Jeffery & French, 1997; Kuller et al., 2001; Skender et al., 1996; Wylie-Rossett et al., 2001).

RELIABILITY AND VALIDITY OF OUTCOME MEASURES

There were eight (47.1%) studies with a primary objective of preventing a disease that used standardized physiologic measures as markers for those diseases, such as glucose, insulin, and/or glycosylated hemoglobin (HbAlc) (DPPRG, 2002; Lasser et al., 1995; Narayan et al., 1998; Oldroyd et al., 2001; Racette et al., 2001; Simkin-Silverman et al., 1995; Wing et al., 1998; Wylie-Rosett et al., 2001). Researchers in 15 (88.2%) studies reported that their outcome measure was anthropometric assessments (Abrams et al., 1994; Campbell, 2000; DPPRG, 1999; French et al., 1994; Garaulet et al., 1999; Haus et al., 1994; Jakicic et al., 1999; Jeffery & French, 1997; Narayan et al., 1998; Oldroyd et al., 2001; Racette et al., 2001; Simkin-Silverman et al., 1995; Skender et al., 1996; Wing et al., 1998; Wylie-Rosett et al., 2001).

All of the physical activity and dietary behaviors were measured via self-report. The majority of measures for physical activity have been widely used, have evidence of reliability and validity, and include four domains of physical activity (i.e., type of activity, frequency, intensity, and duration). The validity of self-reported physical activity was assessed in only three (17.6%) studies, with a half-mile walk test and VO2max (Wing et al., 1998), and accelerometer (Jakicic et al., 1999; Simkin-Silverman et al., 1995). Five (29.4%) studies (Emmons et al., 1994; Jakicic et al., 1999; Simkin-Silverman et al., 1998; Wing et al., 1998; Wylie-Rosett et al., 2001) used the Paffenbarger Activity Questionnaire (Paffenbarger, Wing, & Hyde, 1978) that provides an overall caloric expenditure score for the past week. In 13 (76.5%) studies, researchers used other self-reported physical activity measures that lead to Metabolic Equivalent scores (METs) (Campbell et al., 2000; DPPRG, 1999; Emmons et al., 1999; French et al., 1994; Haus et al., 1994; Jakicic et al., 1999; Jeffery & French, 1997; Mau et al., 2001; Narayan et al., 1998; Racette et al., 2001; Simkin-Silverman et al., 1995; Wing et al., 1998; Wylie-Rosett et al., 2001). Two (11.8%) studies, one focusing on native Hawaiians (Mau et al., 2000) and the other on Pima Indians (Narayan et al., 1998), used physical activity questionnaires adapted to the activities of those cultures. There is evidence of reliability and validity for the adapted questionnaires used for both the native Hawaiians (Mau, Grandinetti, Arakaki, Chang, & Curb, 1997) and Pima Indians (Kriska et al., 1990).

Dietary behaviors also were measured with reliable and valid instruments. The Block Food Frequency Checklist (Block et al., 1986), which assesses kilocalories (kcal) of fats, fruits, and vegetables, was used in eight (47.1%) studies (Campbell et al., 2002; DPPRG, 1999; Emmons et al., 1999; Jakicic et al., 1999; Jeffery & French, 1997; Simkin-Silverman et al., 1995; Wing et al., 1998; Wylie-Rosett et al., 2001). There were six (35.3%) studies (Garaulet et al., 1999; Haus et al., 1994; Oldroyd et al., 2001; Racette et al., 2001; Skender et al., 1996; Wing et al., 1998) that used the Food Frequency Questionnaire (Willett et al., 1985) and analyzed foods reported in food diaries. Two (11.8%) studies reported reliability and validity for food frequency questionnaires developed specifically for dietary behaviors of native Hawaiians (Hankin, Wilkens, Kolonel, & Yoshizawa, 1991) and Pima Indians (Smith et al., 1996). In two (11.8%) studies, food consumption was assessed with more than one instrument or method; Haus and colleagues (1994) and Wing and colleagues (1998) used food frequency questionnaires as well as a 3-day food diary. Jakicic and colleagues (2002) included an eating behavior inventory to assess adherence to healthy eating.

EXTRANEOUS FACTORS

Extraneous factors are individual and environmental characteristics that can influence the intervention effects (Sidani & Braden, 1998). The influences of individual characteristics were examined in several studies. Subgroup analyses were con-ducted in six (35.3%) studies that examined the effects of demographic variables on study outcomes. Specifically, age was significantly associated with outcomes in three (17.6%) interventions (DPPRG, 2002; Schmitz, French, & Jeffery, 1997; Stevens et al., 1993). In the Diabetes Prevention Program (2002), lifestyle intervention out-comes were more positive in older persons than in younger persons. In contrast, in one (5.9%) study by Schmitz and colleagues (1997), younger workers had more positive physical activity outcomes than older workers. Stevens and colleagues (1993) reported that older participants had a greater weight loss, but only at 36-month post-treatment. Gender was not associated with intervention effects in three (17.6%) studies (DPPRG, 2002; Schmitz et al., 1997; Stevens et al., 1993), although physical activity was greater in men than women in one (5.9%) study (Haus et al., 1994) and there was less weight gain by men than women in one (5.9%) study (Jeffery & French, 1997). In regard to race, in one (5.9%) study by Stevens and

colleagues (1993), Caucasians had greater weight loss than African Americans at 6- and 18-month follow-ups, but there was no difference among groups at the 36-month follow-up. The DPPRG (2002) revealed no difference in study outcomes at 3 years according to race. In terms of income and education, one (5.9%) study by Jeffery and French revealed that higher income participants had more positive program outcomes, and in one (5.9%) study by Schmitz and colleagues, the more educated were more physically active. Age, particularly, along with higher income and more years of education, appear to be associated with more positive outcomes.

There were three (17.6%) studies that addressed the effects of baseline weight and weight history on weight loss success. Stevens and colleagues (2001) reported greater weight loss at 6 months, but not at 18 or 36 months, in persons who were heavier at baseline. However, the DPPRG (2002) found relatively greater intervention effects in persons who had a lower baseline BM1. Haus and colleagues (1994) found that those who had gained weight at a younger age and had a greater number of weight cycles (i.e., losing and regaining weight) were more likely to have regained weight at follow-up. Greater weight loss appeared to be associated with younger age, higher education, fewer weight loss attempts, and lower number of weight loss cycles.

Differences in environmental and organizational characteristics were reported in very few studies. Specifically, Emmons and colleagues (1999) reported no differences by setting in study outcomes. Wylie-Rosett and colleagues (2001) evaluated resources used and intervention costs as well as the intervention components. Not surprisingly, resources and costs were higher for the group receiving the most intensive intervention. They also found that completing a self-administered work-book and keeping a diary were helpful in changing behaviors and more workbooks were completed with the addition of computer tailoring and staff consultation. Furthermore, telephone interviews revealed that finding time to use the computer was a problem for workers.

ADHERENCE TO THE INTERVENTION AND RETENTION

Only one (5.9%) intervention examined differences between persons who did and did not engage in intervention activities. Emmons, Linnan, Abrams, and Lovell (1996) found program convenience, scheduling, cost, and program choices and enjoyment to be factors affecting participation.

Adherence to the intervention also determines the dose-response (activities, frequency, duration, and intensity) of the intervention the individual actually received. Indicators of adherence to the intervention were reported in eight (47.1%) studies. Specifically, class attendance was the most common measure of adherence reported in six (35.3%) studies (Jakicic et al., 2002; Jeffery & French, 1997; Narayan et al., 1998; Simkin-Silverman et al., 1995; Stevens et al., 2001; Wing et al., 1998). In one (5.9%) study by Stevens and colleagues (2001), an association was reported between attendance during the first 6 months of the intervention and greater weight loss. Attendance was from 25% (Narayan et al., 1998) to 74% (DPPRG, 2002) at 6 months. At 12 months, attendance dropped dramatically from 10% (Jeffery & French) to 17% (Narayan et al., 1998).

Retention of participants in a study also is important because loss of subjects reduces the statistical power to detect intervention effects (Lipsey, 1990) and threatens internal and external validity (Campbell & Stanley, 1963). Retention of subjects was reported in 15 (88.2%) studies; noteworthy was that retention was greater than 60% at the end of 1 year in five (29.4%) studies (Jeffery & French, 1997; Oldroyd et al., 2001; Skender et al., 1996; Wing et al., 1998; Wylie-Rosett et al., 2001) and for over 1 year in another four (23.5%) studies (Campbell et al., 2002; DPPRG, 2002; Jakicic et al., 1999; Simkin-Silverman et al., 1995). In general, both adherence and retention decreased greatly over time.

Attrition was relatively greater in older women (Garaulet et al., 1999), blue-collar workers (Jeffery et al., 1993), low-income women (Jeffery & French, 1997), and African Americans in the diabetes prevention program of Racette and colleagues (2001). Emmons and colleagues (1999) found that older, male, and more educated white-collar workers had the lowest attrition and completed surveys at all three data collection points. In other studies, attrition tended to be lower for persons who had an impending illness trajectory such as diabetes (DPPRG, 2002, Narayan et al., 1998; Oldroyd et al., 2001; Wing et al., 1998) or hypertension (Stevens et al.,

1993). Wylie-Rosett and colleagues (2001) found no difference in the characteristics of dropouts in a study including HMO enrollees compared to those who completed the study.

There also appears to be variation in dropout by treatment condition. Women in the Health Works for Women study (Campbell et al., 2000) dropped out of a delayed-intervention control group faster than the intervention group, and the investigators offered part of the intervention 6 months early to retain them in the study. In contrast, Racette and colleagues (2001) reported that 71% of the control group returned at 1 year compared to 42% of the treatment group. Skender and colleagues (1996) reported a higher attrition in the diet-only intervention than in the exercise-only or diet-exercise combination groups. In contrast, Wing and colleagues (1998) reported attrition to be lower in the diet condition and higher in the exercise and diet-exercise combination conditions. Garaulet and colleagues (1999) found that participants who had a very high baseline BMI reported excessive duration of the treatment as the main cause for drop-out. Reasons for dropping out of studies were travel and vacations, time constraints, wanting a "faster or fad" diet, family and social pressures, treatment duration, failure to understand the diet, and health problems (Garaulet et al., 1999; Oldroyd et al., 2001; Racette et al., 2001). Other reasons were lack of transportation, need for child care, alcohol-related problems and other social factors, and high intervention staff turnover (Narayan et al., 1998).

EFFECTIVENESS OF THE INTERVENTION

Table 2 in the last column shows the results of outcomes for comparison for the treatment and control groups. The interventions were effective in achieving the desired outcomes in 11 (64.7%) studies (DPPRG, 2002; Emmons et al., 1999; Garaulet et al., 1999; Haus et al., 1994; Jakicic et al., 2002; Mau et al., 2001; Oldroyd et al., 2001; Simkin-Silverman et al., 1998; Skender et al., 1996; Stevens et al., 2001; Wing et al., 1998). However, it is unclear from these studies which specific elements of the intervention were most efficacious. Intervention effectiveness does not appear to be associated with the number of components, intensity, or duration of the intervention. The two (11.8%) interventions using individual computer programs (Campbell et al., 2002; Wylie-Rosett et al., 2001) and two (11.8%) for minority groups (Narayan et al., 1998; Racette et al., 2001) were not statistically significant for producing changes in physical activity and dietary behaviors.

DISCUSSION

This review was based on a framework recommended by Sidani and Braden (1998) to evaluate intervention processes. There are other ways to frame the findings though. In addition to Sidani and Braden's framework, this review can be framed based on the results of the Behavior Change Consortium (Ory et al., 2002) or RE-AIM (Reach, Efficacy, Adoption, Implementation, and Maintenance) (Glasgow, Vogt, & Boles, 1999). Whatever framework is selected, the lessons learned from this research synthesis seem to be supported from each of these perspectives. Some of the conclusions possibly that have been tacit in the past can now be confirmed by the lessons of this review.

Before concentrating on lessons learned, there are several noteworthy strengths of the studies. First, a majority of them used a randomized controlled design or a quasi-experimental design and large sample size, increasing their ability to detect intervention effects if they were present (Lipsey, 1990). Second, randomization in many studies occurred by communities and worksites rather than individuals to prevent intervention and control group contamination effects. Third, the interventions were directed toward a variety of well-defined clinical goals such as promoting healthy behaviors, reducing or maintaining weight, or preventing a specific illness. Fourth, length of studies was adequate to assess both short- and long-term effects, providing important information for future research. Outcomes of the studies varied depending on the goal of the intervention, but the results showed that many interventions ended in positive behavioral and/or physiologic changes. Last, investigators are calling for more focus on process variables to identify which intervention works for whom, under what conditions, and how much intervention is required (e.g., Glasgow et al., 1999) as well as concentration on theory and combining individual and environmental approaches (Dzewaltowski, Estabrooks, & Glasgow, 2004; Ory et al., 2002).

The overarching lesson learned from this descriptive review is to focus on process evaluation (internal validity) and to "decompose interventions," which was not done in the extant literature reviewed. There is a dearth of

information in the published studies reviewed necessary for replicating and/or improving interventions and deciding the amount of intervention necessary, the components that are effective, and for whom the program is most suitable and viable. The lessons learned specific to internal validity are presented in Table 3.

TABLE 3. Checklist of a Dozen Lessons Learned

Check	Issues	Actions
☑	1. Theory connected to program components and outcomes	Identify and express connection among theory, problem, definition, critical inputs, outcomes, and extraneous factors.
☑	2. The program and its components need to be relevant to problem	The problem needs to be explicitly stated and addressed by the program and its components.
☑	3. Practicality and feasibility	Focus on intervention realism for implementation in "real-world" settings by staff with multiple demands and responsibilities.
☑	4. Preference in change strategies	Participants decide on which strategies are suitable for them.
☑	5. Pedagogy	Concentrate on sound health pedagogy to focus on individual differences such as in mental age, learning styles, and literacy levels.
☑	6. Moderating variables and extraneous factors	Measure and report differential effects in performance of moderating variables or extraneous factors (e.g., place, organizational settings, social circumstances, demographics, psychographics, culture, and literacy).
☑	7. Recruitment, retention, intervention adherence, and relapse	Develop and report on strategies effective for recruiting and retaining participants. Address issues relevant to adherence and directed toward the integrity and fidelity of the intervention and concentrate on relapse prevention strategies.
☑	8. Dose-response/strength	Identify and report components that are efficacious and how much is needed, how often, and for whom.
☑	9. Therapeutic index or safety factor	Measure and report positive and ill effects of the intervention.
☑	10. Process evaluation	Comprehensive assessment and reporting of issues to assess integrity and fidelity of the intervention as well as measures of behavioral, quality of life, and participant satisfaction outcomes. Address infusion of intervention to ascertain what was learned from program components.
☑	11. Dependent variables	Include measures that are reliable and valid and continue efforts to develop "gold standards" in assessments of dietary and physical activity behaviors.
☑	12. Sustaining intervention effects	Refocus on individual acceptance and intervention appropriateness.

LESSON 1

The first lesson is that an explicit theoretical model is essential for organizing intervention components and explaining the causal processes thought to mediate the relationships between the intervention and outcomes (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997; Sidani & Braden, 1998). Theory should be used to describe the content in the "black box," and this allows identification of specific causal processes to be tested.

For example, do educational approaches to improving physical activity and diet help to increase knowledge, change attitudes and beliefs, and thereby improve the behaviors? Are different intervention components equally effective for both physical activity and diet, or is one component more effective in enhancing physical activity than in changing diet? Even in studies with intervention elements based on constructs of behavior theory (e.g., self-efficacy, attitude toward the behavior, social support), the effects of the intervention on these constructs as mediating processes were not examined or at least not reported. Providing conceptual and theoretical underpinnings for problems allows interventionists to know what to expect, as well as when and why (Lipsey, 1990).

LESSON 2

The behavioral problem needs to be explicitly stated and the intervention and components need to be relevant to the problem. In the reviewed studies, the problems were defined in general terms of physiologic association with clinical conditions. However, none of the articles provided clear and explicit explanations of the behavioral problems associated with lower levels of physical activity or poor dietary behaviors that place the study populations at a higher risk for the clinical conditions. For example, if it had been stated that the intervention was designed to focus on the problem of participants' lack of skills to master barriers to improving diet and exercise, then this might sharpen the focus of components, exercises, and homework assignments. In addition, the problem statement should include for whom and under what circumstances these problems occur.

LESSON 3

Many of the interventions investigated may not be practical for clinical settings and not exportable. The focus of the research tends to be on intensive, expensive, and demanding interventions in rarified, controlled conditions in treatment centers using rigorous research protocols. Such an "efficacy" paradigm admirably strives to ascertain whether an intervention can produce dramatic effects among all participants, but does not address how well a program works in "real world" settings (Dzewaltowski et al., 2004; Glasgow et al., 1999). One possibility for simplifying and organizing intervention components/techniques and increasing positive outcomes is to operate from a trans-theoretical perspective and to use trans-behavioral components that have diverse and widespread application across heterogeneous determinants/ moderating variables of behavior leading to improved outcomes. Perhaps the norm needs to be the use of trans-theoretical and trans-behavioral techniques such as problem solving (e.g., Chang, D'Zurilla, & Sanna, 2004) and motivational interviewing (Miller & Rollnick, 2002).

A second strategy that may lead to intervention parsimony and efficiency is to examine the influence of one behavior over the other or the composite or synergy of the two behaviors. Understanding the mechanisms associated with and the complex relationships of physical activity and dietary behavior change processes will help develop better interventions and therefore become an important issue for future research (e.g., Strecher, Wang, Derry, Wildenhaus, & Johnson, 2002).

A third strategy is to use simpler interventions first and follow with more intensive interventions as needed or required to achieve desired health effects (Black & Hultsman, 1989-1990). The underlying notion is that "less" may be "more" and self-regulation may be better than complex, multifaceted intervention or "usual" care. A series of self-administered interventions could be used first. Such self-administered interventions are viable alternatives to usual care because these interventions offer a means to extend reach, efficiency, and efficacy. Other advantages are that these interventions can be shared, disseminated, reused, and could include peer helpers to help administer programs (Black & Cameron, 1997; Black & Scott, 1996).

LESSON 4

Interventions need to be designed that are targeted versus diverse. The notion, in some instances, has been to provide a "smorgasbord" of techniques and strategies in hopes of providing a "powerful intervention." Participants are expected to select the techniques and strategies that will work best for them in hopes of a homogenous (negligible standard deviation) impact. The assumption is "more is better" because participants

will somehow find what they in particular need to be successful. The liability is that attempts to increase the efficacy or enhancement risks intervention feasibility and may result in "intervention fatigue."

LESSON 5

Adherence to sound health pedagogical principles should positively impact pro-gram efficiency and efficacy. Health pedagogical issues were not addressed in the studies. Programs and components should be designed around clear statements of vision, mission, core values, aims, goals, and change and learning objectives. Designing and/or selecting programs and components in this manner should guide process, outcome, and impact evaluation. Other related important health pedagogical considerations are to discern mental versus chronological age, best means of learning (e.g., visual, auditory, and kinesthetic), and literacy levels in order to homogeneously group participants according to learning potential. Utilizing a systematic health pedagogical approach ultimately should lead to data relevant to "individual differences" and a dose-response relationship.

Also there needs to be greater attention and focus on individual differences related to learning such as learning styles, cultural sensitivity, and change preferences. No longer is it appropriate to operate as if "one shoe size or intervention fits all." There needs to be intervention options tailored to the various ways people learn and to their preferences about how they wish to learn. As Green (2001) poignantly stated, "We need to consider within-study individual and group differences, rather than try to nullify them through processes of randomization to groups" (p. 175). The issue is to determine what works for whom and how much is needed to reach personal behavior goals/objectives.

LESSON 6

There needs to be greater focus on moderating variables and extraneous factors. Researchers need to conduct and report interaction effects of moderating variables and subgroup analyses or use qualitative methods to identify how and why the intervention worked for some individuals and did not work for others. The studies reviewed showed conflicting findings related to gender, race, or age in those studies that did examine subgroup differences on study outcomes. Intervention choices need to be provided appropriate to such factors as setting, culture, spirituality/religious affiliation, and primary language. Having this information would be helpful to provide interventions designed specifically for certain subgroups that have different characteristics.

LESSON 7

Recruitment, retention, intervention adherence, and relapse need to be routinely measured and reported. Participants should be recruited who need the intervention the most rather than those who might change independently without intervention or devise a minimal intervention on their own. In many of the studies, participants volunteered, which could potentially introduce a self-selection bias.

Retention of participants in both intervention and control groups also was a problem in many studies, threatening the internal validity when there was a differential loss of participants (Campbell & Stanley, 1963). Most researchers examined the effects of attrition on the equality of treatment and control groups. Many researchers used multiple strategies such as a worksite coordinator to serve as an advocate for the intervention, removal of barriers such as parking or transportation fees, offering special events, and newsletter contacts to keep participants in the study. Additional strategies are needed to minimize attrition such as a focus on particular segments of the population based on gender, racial/ethnic, or socioeconomic groups (Shumaker, Dugan, & Bowen, 2000).

Adherence to the intervention was a recurrent problem in the reviewed studies as well as in other intervention research (Martin, Bowen, Dunbar-Jacob, & Perri, 2000). Overall, there was no common or frequently reported cause of poor adherence to the dietary and physical activity interventions. However, seasonal, social, and cultural variations in the physical activity and diet could account for poor adherence (Sherman et al., 2000; Uitenbroek, 1993). Consideration of these variations at data collection points is critical in that physical activity and diet fluctuations can adversely influence the desired outcomes of an intervention (Sidani & Braden, 1998). Also, investigators need to investigate and report variables related to integrity and fidelity of the intervention.

Strategies to avoid study attrition offered by Shumaker and colleagues (2000) are to educate staff about "cues" prospective participants give in the initial interview (e.g., history of poor adherence to other studies or difficulty in scheduling appointments or reaching participants by phone) and to fully inform prospective participants during the recruitment process about the importance of adherence. Future research is needed to help understand who is and who is not influenced by particular intervention programs. People with different characteristics may need to be targeted with different messages and intervention strategies to keep them in a study and to keep them involved with an intervention.

Relapse also needs to be investigated as a central and independent problem. Behavioral models that include relapse prevention need to be refined and thoroughly investigated. Identifying predisposing/determining factors is a priority along with refinement of measures to assess relapse and better data analytic strategies for assessing behavior changes. For example, the cognitive-behavioral model of relapse could be used to direct this research (Witkiewitz & Marlatt, 2004).

LESSON 8

The dose-response relationship or "biological gradient" is important to investigate. The interventions included multiple components, seemingly leading to strong interventions as evidenced in their significant effects on outcomes. However, it was difficult to determine the exact intervention dose delivered because the description of the intervention frequency and duration were vague. In addition, justification for the strength (dose) of the treatment or information about whether the intervention delivery was standardized was included in only a few of the research reports. This lack of information hinders the ability to make judgments about the integrity of the treatment.

Another issue related to dose-response relationship is length of the intervention and study period. Overall, the study period appeared to allow adequate time for the intervention effect to occur as well as adequate observation time to assess the duration of the effect. In general, the maximum change was early in the intervention, at about 6 months, and the intervention effects declined after 6 to 8 months. There is still a need to examine approaches to sustain behaviors over time and cost-effectiveness of the intervention and each component needs to be ascertained in regard to dose-response.

LESSON 9

The therapeutic index or safety factor is important. The question is, "What are the ill or untoward effects of interventions or components, and what other unplanned outcomes occur?" No intervention has a single effect or outcome (Black & Laflin, 2003). It would be beneficial to assess and report any short- and long-term harmful effects and their severity.

LESSON 10

It is important to ascertain what specific intervention components were effective in bringing about change in dietary and physical activity behaviors. Specifically, data are sorely needed about which components of the intervention were most and least effective and under what conditions the desired outcomes were or were not achieved. Reporting analyses about these issues relevant to the efficacy of components is a high priority.

LESSON 11

It is important to select dependent variables that are relevant to program goals and objectives, are most precise, and are consistent in measurement. An issue is that many of the findings reported by investigators are based on self-reported physical activity and diet behaviors, which can lead to response bias and challenges to reliability and validity (Kristal, Andrilla, Koepsell, Diehr, & Cheadle, 1998; Montoye, Kemper, Saris, & Washburn, 1996). Efforts are needed to develop and test precise measures of physical activity and diet behaviors since change in these behaviors can occur slowly, making it more difficult to detect a change if one is present. In addition, more investigators might include objective measures such as heart rate monitoring or step counters and food diaries to validate self-reported physical activity and diet.

LESSON 12

It is important to sustain intervention effects over prolonged periods of time. Perhaps a solution is to design interventions that are sustainable. Relevant issues are readiness to change, learning preferences, acceptance of the problem to change, endorsement and belief in the intervention, and parsimony and efficacy of the intervention to promote routine use. Refocus on and further considerations of this important issue are needed.

SUMMARY

These are 12 main messages from this review which emphasize that process evaluations and decomposition of interventions aimed at both promoting a healthy diet and increasing physical activity are needed. Future research should continue with the strengths and address the limitations highlighted in this review. Interventions should be grounded in theory so specific mechanisms of change are identified in relation to the desired outcomes. The problem needs to be defined to include the how, when, and where of the problem; factors that cause the problem; and the degree of the problem requiring attention. Intervention components need to be relevant to the defined problem. They need to be addressed by the intervention and to strive for parsimony so as to be applicable to "real world" settings. Participants should be able to decide which change strategies are most appropriate for them-selves. Sound health pedagogical principles and strategies for teaching need to be used. Moderating variables need to be addressed in study designs. Issues related to recruitment, retention, and adherence need further attention to include the integrity and fidelity of the intervention. The dose-response relationship needs to be carefully examined as well as the therapeutic index or intervention safety factors. Process variables must take a prominent role and opportunities for reporting must become a priority in order to know what works for whom and under what conditions. Dependent variables need to be selected that are appropriate for pro-gram goals and objectives and are reliable and valid. Building on previous study strengths and addressing their limitations will lead to greater insight about the over-all effectiveness of particular interventions, the complexity and strength of the intervention needed to achieve optimal behavior change, as well as the multiple individual and extraneous factors that have both direct and moderating effects on the desired behavioral outcomes.

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